

CIRCULAR, No. 6.

REFLEX PARALYSIS.

Surgeon General's Office, March 10, 1864.

89

CIRCULAR No. 6.

REFLEX PARALYSIS.

London General's Office, March 10, 1884.

Circular, No. 6.

Surgeon General's Office,

WASHINGTON, D. C., *March 10, 1864.*

The following paper on Reflex Paralysis, the result of gun-shot wounds, founded chiefly upon cases observed in the U. S. General Hospital, Christian Street, Philadelphia, by S. WEIR MITCHELL, M. D., GEORGE R. MOREHOUSE, M. D., and WILLIAM W. KEEN, Jr., M. D., is published for the information of Medical Officers, in the belief that immediate and practical benefit may be derived from it.

JOS. K. BARNES,

Acting Surgeon General.

Since the establishment, in May, 1863, of a Special Hospital for the treatment of diseases and injuries of the nervous system, a vast number of cases of gun-shot and other injuries of nerves have been studied by the authors of this paper.

The great mass of these will be considered in a future essay, upon the history, results, and treatment of gun-shot wounds of nerves. We have judged it wise, however, to report separately a class of very infrequent cases, in which paralysis of a remote part or parts has been occasioned by a gun-shot wound of some prominent nerve, or of some part of the body which is richly supplied with nerve branches of secondary size and importance.

So far as we are aware, the Medical Histories, which we are about to record, stand alone as the first reports of sudden reflex paralysis from mechanical injuries. How they differ from the paralytic affections which result from disease of organs, and which have been so ably treated of by numerous authors, we shall presently consider. That they have thus far escaped notice may be easily accounted for. In the first place they are rare; among some sixty or more carefully studied instances of wounds of nerves, we have met with only seven cases of reflex paralysis of remote organs, in which the influence was prolonged or severe. In the majority of cases, the reflex effect is either very slight or very transient, and for one or both of these reasons, unlikely to attract notice from surgeons on the battle-field, or in Division or Corps hospitals, where their brains and hands are taxed to the utmost, by the palpable misery of wounds in the early stages of treatment. Had it been otherwise, we do not doubt that numerous cases of reflex paralysis from injuries to nerves would have been recorded.

the next. His manner was excited and hysterical. He talked incessantly, and his limbs were in continual agitation, with occasional twitching of the facial muscles. The tympanal membrane was split across in his left ear, and on the right side presented a triangular opening. He had no headache, but complained of the roaring, hissing, etc., which seemed to be sources of the utmost annoyance. Despite his desire to move about, his muscles were extremely feeble, and for twenty-four hours he was unable to walk without aid. He recovered readily; both membranes healing completely, and his hearing none the worse for the accident.

The patient, it should be noted, was not injured by his fall, and as we have seen, showed no signs of concussion. He, as well as his medical attendant, attributed the phenomena which he exhibited, to the shock given to the auditory nerve. This opinion has since been confirmed by the cases reported by M. BROWN-SÉQUARD, and others.

Further on we shall show that in rare cases gun-shot wounds cause partial or very general paralysis of grave type and prolonged duration in parts not directly injured: we shall also show that these protracted paralyses must be due to an equally permanent affection of the nerve centres. Now, if this be possible, there is every reason to believe that a temporary, though general, paralysis may take place in a large number of gun-shot wounds. When the cardiac centres feel the shock most severely, the feebleness will of course be greater; but there is much reason to suppose that the cerebral and spinal centres in general, suffer *en masse* in every case of loss of consciousness from shock.

As we proceed, we shall have occasion to discuss the mechanism of the more permanent forms of reflex paralysis. Here we desire only to show that the effect of grave wounds is to cause a condition of the centres which gives rise to a general and profound feebleness, and that in rare cases the central effect is so intense as in some way to cause paralysis, which may last for hours, days, or months.

Another class of nerve affections demands some notice before we discuss the undoubted instances of reflex paralysis from wounds which have fallen under our notice. These are what the French writers call cases of injury from commotion. They differ from those we have described in being due to the mere mechanical effect produced upon the neighboring parts. If, for example, a ball passes near the spinal column, it is conceivable that the roll of its motion, and the resistance of the tissues, may determine in the spine a brusque and sudden oscillation of the contents, sufficient to cause very grave results.

We have sometimes seen this illustrated in a very interesting shape, and in a less dangerous form. Thus, in the case of a soldier who was shot at Gettysburg, July 3, 1863, the ball entered the cheek, and passing outside of the ramus of the jaw, was cut out of the trapezius muscle. It struck the ramus, but did not fracture it, or interfere with the act of mastication. In October, one or two very minute morsels of bone escaped from the neck, in front of, and four inches below the jaw. The only injury to the jaw-bone must have been on its exterior surface, from which the pieces of bone alluded to worked down the tissues of the neck. The shock caused complete paralysis of the inferior dental nerve, with absolute anæsthesia, analgesia, and loss of sense of temperature in the lower lip and chin of the injured side. The sensation was for the most part rapidly restored by the use of cutaneous faradization, after the nerve had been allowed time to recover from the results of the shock it had sustained. A portion of the lip, the skin below it, and the mucous membrane within, still remain rebellious to treatment.

The other case of mechanical shock to a nervous structure, we shall report more at length. It is one as to which there may reasonably exist some doubt, whether to call it an instance of commotion of the spinal cord, from injury of neighboring parts, or to regard it as an impression made upon the spinal centre through the injured nerves, and resulting in a paralysis, as the reflected result of the state into which the centres were thus thrown. It is impossible to be sure that both sets of causes may not have been at work.

FLESH WOUND OF BACK OF NECK; ENTIRE APHONIA AND PARALYSIS OF ALL FOUR LIMBS; SPEEDY RECOVERY, THE RIGHT ARM REMAINING WEAK.

MORGAN EMORY, *æt.* 20, farmer, born in New York, enlisted September, 1861, in company "C," 9th New York Cavalry, a healthy man. August, 1862, had typhoid fever, but recovered perfectly.

On the seventh of July, 1863, he was wounded at Williamsport. The ball passed through the neck from side to side, posterior to the vertebrae, entering the left side one-half inch below the level of the angle of the jaw, and two inches from the posterior middle line of the neck, and emerging on the right side at one-fourth of an inch lower down, and two and a half inches from the same middle line. No bone has been discharged from the wound, nor is there any evidence of injury of the spinous processes of the vertebrae.

Effect of wound.—He fell from his horse, striking upon his right shoulder, and bruising it slightly. He was speechless for fifteen minutes, and could neither stand, nor move either arm. He acquired partial use of his left arm and of his legs in three or four days, and in a week could walk; his right arm improved very little.

September 21, 1863; present condition.—With the exception of slight numbness of the left hand, his right arm is his only trouble. He has no power to move the right shoulder and elbow joints; the wrist and fingers he can move slightly. He has a burning pain in the fingers, most marked when the hand is cold. Sensation of touch is generally good. The circulation in both hands is bad—the right is colder than the left—the right biceps and pectoralis major are hyperæsthetic.

Galvanic test.—Electro-muscular contractility and electro-muscular sensibility, slightly diminished in all the muscles of the right arm. The shoulder joint is susceptible of passive movement, and seems not to have been injured permanently by the fall; the shoulder muscles are not wasted. It seems that for some days after the wound his skin was hyperæsthetic from the level of the wound down to the waist, so that a fly on the skin gave pain, although deep pressure did not. The muscular hyperæsthesia is of later date.

Treatment.—Douche to arms; passive motion and electricity to right arm and shoulder.

Three weeks later the electro-muscular contractility of the shoulder muscles was as good as on the other side. In the triceps the electro-muscular properties were lessened; in the forearm and hand both were as usual. Continued to faradize daily. The faradization was used up to November 1st, when he was furloughed. At this time the electro-muscular contractility and sensibility of the muscles were as good on the right side as on the left.

He has recovered all the motions of the elbow, wrist, shoulder and hand, but all are more feeble than those of the left arm, which is still a little numb, although far less so than when admitted.

The burning pain which at first annoyed him is now rarely felt, and the

hyperæsthesia of the muscles is nearly gone. On his return from furlough he was still better, and within a month was returned to duty.

The fall upon the shoulder was incompetent to cause all of the symptoms here described, and since, in other cases where this element of doubt was absent, we have seen paralysis caused by commotion, therefore we see little reason to hesitate in assigning it as the producing cause of the paralysis in the present case; moreover, there was no paralysis of cerebral nerves, and the loss of power lay chiefly in the range of those nerves over whose spinal origin the ball passed.

In many of the cases of injuries of the brachial plexus which we have observed, it was quite impossible that the nerve tissue could have been directly injured by the ball, and in some of these at least the resultant paralysis must have been due to brief compression of their trunks during the movement of the missile or to agitation of the nerves through the tearing of tissues more or less remote.

As we shall return to this subject in a future essay, it is only necessary here to describe cases of commotion, so as to separate them from those of true reflex paralysis with which they might easily be confounded. We have met with another and very interesting form of paralysis, which might possibly be mistaken for reflex paralysis by a superficial observer. Men who are forced to use crutches, and to bear heavily upon them, are sometimes affected with numbness of one or both hands, and even with loss of motion in these members. This result is due to pressure upon the axillary nerves. It is most apt to occur in emaciated persons and those of large frame. Where it presented itself early in the case, as it may do, it might readily be attributed to reflected irritation. It is then easily relieved by laying aside the crutches, or by padding them and adding a handle by which to support the weight of the body on the hands. When the cure is delayed, faradization always affords prompt relief.

We have seen that in all probability the state of shock from gun shot injuries is a state of general paralysis. We have also seen that in the great mass of cases it is temporary. We have now to show that in rare instances the paralysis continues as a more or less permanent evil, after the general depression has passed away. When, therefore, a wound occurs, and the patient surviving the first effect is found to have paralysis of a distant limb or limbs, it is impossible to deny to such cases the title of reflex paralysis. All of the following instances seem to us to have fulfilled every condition, which would entitle them to be so considered:

CASE I.—BALL WOUND OF RIGHT SIDE OF THE NECK, PROBABLY INVOLVING NO IMPORTANT NERVE DIRECTLY; FRACTURE OF HYOID BONE; WOUND OF THROAT. REFLEX PARALYSIS OF LEFT ARM; PROBABLE REFLEX PARALYSIS OF RIGHT ARM; EARLY RECOVERY OF LEFT ARM; PARTIAL AND REMOTE RECOVERY OF RIGHT ARM.

Captain R. N. STEMBLE, U. S. N., *æt.* 49. While commanding the ram Cincinnati, May 10, 1862, the ship was attacked by two rebel rams. Captain S. was aiming a pistol when a ball entered his right neck, broke the hyoid bone and traversing the neck, emerged three and a half inches from the middle line, above and to the right of the superior angle of the scapula, through the edge of the trapezius muscle. He fell half conscious and confused, but soon reviving, felt that *both* arms were paralyzed. His first impression was that he was shot through both arms. He was carried below in great pain, and spitting blood freely. The pain in the arms was made worse by movement and by passive motion. Pressure gave pain in the right arm and shoulder only, and in the right chest. Sensation was never entirely absent from either arm, but was dull in both.

His medical attendant, Dr. JUDKINS, of Cincinnati, who took charge of his case on the 19th of May, 1862, writes as follows: "When first seen by me the anterior wound was discharging mucus and pus, with saliva. His voice was hoarse; deglutition, which returned in part on the third day, was still difficult and painful. He experienced severe pain in the supra hyoidean group of muscles and in the pharynx. His left arm was still slightly paralyzed, having rapidly improved. On the right side the deltoid, biceps, triceps, and brachialis anticus were completely paralyzed, and up to the date of this account, July 9th, 1862, have improved very little. The muscles of the right fore-arm are nearly as much paralyzed as those of the arm, and the sensibility of the right arm has become painfully acute. Captain S. seems also to have lost to a great degree the use of most of the shoulder muscles on the right side."

The left arm was nearly well in four weeks, the sensibility and movements of both improving equally, so that now, July 18, 1863, he has no loss of function in the member, except slight want of tactile sensation in the ultimate distribution of the ulnar nerve. The right arm was but little better at this date, but the fore-arm had acquired every movement except supination, which seemed to be limited about one half, not by paralysis, but by contraction of the opponent group of pronating muscles. At this period, sensation was entire in the right limb, but there was soreness on pressure in all the anterior arm muscles, and neuralgia in the arm and fore-arm. The nutrition of both arms was good, but the right was the smaller, measuring at the biceps $9\frac{1}{4}$ inches, while the left measured $10\frac{3}{4}$ inches.

During the slow progress of his case, Captain STREMBLE lost several small pieces of the hyoid bone, and although hoarse for many months, has recovered his voice, without serious change in its tone or power.

His convalescence, interrupted by many accidents, and by an attack of pneumonia, continued up to the summer of 1863, and was largely due to the skill and care of his able medical attendant, Dr. JUDKINS. When placed under treatment, in Philadelphia, by Dr. MITCHELL, July 18, 1863, Captain S. was still suffering from constant pain in the right arm. The left was well except as to the trifling loss of sensation mentioned above. The right fore-arm, though weak, possessed every movement except supination, as did also the hand, but the arm hung at the side useless, because there was scarce any abducting power and very little flexion at the elbow, both the biceps and long supinator being greatly enfeebled, and the former muscle, as well as the brachialis anticus, almost entirely atrophied and lost to view. Excepting the trapezius and rhomboid muscles, all the shoulder group was nearly useless and partially wasted.

From July 18 to September 9 he was faradized; at first every day, and then every third day. Active and passive movements, which had already been employed, being of course continued. The result was a steady gain, ending in a cure as complete as could be hoped for in a case so severe. He regained every lost motion, and could raise his hand to his chin and abduct the arm about fifty degrees. The pronators alone remained intractable, despite every effort, but as the supinators and biceps developed themselves largely, even pronation gained somewhat, though not to such an extent as the other movements. The pain and hyperaesthesia diminished, but the former still exists. It is believed that a second course of similar treatment, about to be instituted, will further amend this case, in which all other means had utterly failed.

Dr. JUDKINS is of opinion that the entire paralysis was due to reflected irritation. We incline to this belief for anatomical reasons, but even though we admit that the paralysis of the right arm may have been

caused by commotion of the brachial plexus, it is impossible to suppose that the loss of power in the left member could have been similarly produced. The only permanent lesion on that side was the loss of feeling on the ulnar side of the palm and fourth finger. With this exception, it regained its normal functions within three or four weeks. Whatever may have been the cause of injury to the right arm, it appears to have involved more or less, nearly all the strands of the plexus, which is unusual in cases of traumatic injury from a ball. Its results were also more lasting than in the other arm. A year and two months after the accident the right arm was a useless member. Faradization, of the muscles affected, restored their power very rapidly, so that the patient regained every movement of the limb, which is still improving; electricity having been temporarily laid aside in September, 1863.

CASE II.—FLESH WOUND OF RIGHT THIGH, WITHOUT WOUND OF ANY LARGE NERVE; COMPLETE PARALYSIS OF ALL FOUR LIMBS; SPEEDY RECOVERY OF THE LEFT ARM, TARDY RECOVERY OF THE OTHER LIMBS; SUBSEQUENT ANALGESIA OF THE RIGHT SIDE.

JACOB DEMMUTH, *æt.* 21, Swiss, enlisted July, 1861, company "D," 108th New York Vols., a man somewhat below the average standard of height, of lymphatic temperament, and moderate intelligence. Reports himself as healthy up to the date of his wound, which took place at Fredericksburg, December 13, 1862. He was marching at double-quick, when a fragment of shell, as large as a musket ball, struck his right thigh, at the junction of the upper and middle thirds, directly over the femoral artery. The fragment did not enter deeply, but merely lodged in the leg, and was removed a day later without injury to the vessel.

Effect of wound.—He fell half conscious, and although aware that he was wounded, he could not fix on the site of the injury until he had examined the limb. He felt instantly a burning pain in both feet, in front of the right chest and in the right arm, and in the right thigh about the wound. At first he was entirely powerless, but after a few minutes the power of the left arm returned, leaving him paralysed as to motion in the right arm and in both legs. He lay on the field twenty-four hours, the weather being very cold.

Sensation was defective in all the parts paralysed as to motion. He had no pain in the back, but the burning pains alluded to above continued for a long time, and were always eased by cold applied to the wound. While the wound was healing he had headache and difficult, painful micturition. The wound closed in four weeks. During this period he regained the power to move the right arm, feebly and slowly although perfectly as to extent. The pain in the side and feet also diminished, and the former disappeared altogether at a later period. He could not stand, however, or lift his legs from the bed at the time the wound healed, but there was then no headache or difficulty with the bladder or rectum.

January 28, 1863, he was sent to Washington, where he improved so as to be able to walk with the help of a cane. His subsequent transfer to West Philadelphia caused a relapse; the pains returned, the paralysis increased, and he walked with difficulty on crutches.

June 4, entered Christian St. Hospital.

Present State.

Movement.—The patient is partially paraplegic. He has some power to move the thighs when lying down, but cannot lift the legs from the bed. Below the knee all motion is lost, except a slight power of flexing the smaller toes in both feet. Pressure upon the cicatrix causes feeble twitching of the anterior muscles of the right thigh; both legs are subject

to cramp and twitchings, which increase at night. The left arm is strong, the right arm has all the normal movements, but all are slowly and feebly executed.

Sensation.—He has shooting pains which start from the seat of the wound, and dart down the thigh to the knee. No other pain exists at present, but there is still a good deal of burning sensation in both feet alike. Localizing sensibility perfect everywhere. Tactile sensation normal, or very nearly so, in all parts of his body; no loss of sense of pain in the skin. Pressure or pinching of the muscles gives him more than the usual pain, so the muscles (of both legs, especially below the knees,) may be regarded as affected with hyperæsthesia of common sensation. The left arm is in all respects normal; the right arm is also free from lesions of sensibility.

Nutrition.—There is no special atrophy of individual groups of muscles, but both legs are slightly wasted, the right arm not at all so. The legs below the knees are relaxed and cold; the feet are congested, but not swollen to any marked extent. Along the edges of both soles there are singular purple and blue mottled spots, which he says existed from the time his boots were first taken off, twenty-four hours after he was wounded. It is possible that these marks are due to frost bite. The muscles of the legs are about equally irritable to induced electric currents. Unfortunately, no very perfect electric examination of their condition was made at this period.

Treatment.—Regarding the case as one of reflex paralysis chiefly, he was ordered to have rough frictions, with cold to the spine, and to take the twentieth of a grain of strychnia three times a day. Under this treatment, the cramps and twitchings increased, so that after three weeks the strychnia was abandoned. Every future attempt to repeat its employment caused the same increase of annoyance, without correspondent benefit, so that it was finally laid aside as useless or worse. About the middle of August a blister was placed on the cicatrix, with the effect of greatly relieving the burning in both feet. At the same time he was ordered to use the hot and cold douche to the spine alternately, and faradized daily. The electricity was persistently employed during two months, and a month later he was also treated with iron and quinine, porter and liberal diet. The electric treatment caused a rapid amelioration of his case, so that he soon left his bed and began to walk on crutches. Early in November he ceased to improve, and the treatment was abandoned. At this time he could use his right arm well and quickly, and walked unaided, although with a little unsteadiness of gait.

No close examination was made as to his sensibility until December 3, 1863, because during this time he had been able to give aid in the wards and made no complaint, except of more or less constant aching in the dorsal and lumbar regions of the spine. About December 3, he was closely inspected for discharge, when the following notes were taken:

Motion.—Good in left arm; not so perfect in right arm. Both legs somewhat weak, so that he shuffles a little in walking, the worst movement being that of extension in the toes of the right foot.

Sensation.—Tactile sensibility feeble in the right leg and right arm, but nowhere entirely lost; it is normal in the left leg and left arm. The sense of touch is first found to be feeble below the navel on the right side. It lessens in perfection to the knee, and is better below that part, especially on the inside of the calf, being worst in the foot. Tickling the sole causes no sensation of tickling on either side.

Pain.—There is absolute loss of sense of pain in the right leg, belly, chest and arm, with somewhat lessened sensibility to pain on the left side

also. In many localities he was able instantly to tell by the altered sensibility when the needle point crossed the median line; in others, this was more difficult. So complete was this analgesia, that the most intense faradization of the nails of the right hand, or of the right nipple, caused not the least sensation. The penis remained sensitive, but all over the right side he could be cut or stuck full of needles without evincing the least consciousness of anything but a touch.

The sense of temperature was good in the left leg, confused and uncertain at the upper third of the right thigh, and lost below the knee, where a heat of 110° Fahrenheit was felt as a touch only, when the sponge wetted with hot water was applied. On the foot of the right side this degree of heat was unfelt in any form. Higher heat caused reflex movements, which did not tend to remove the limb from the irritant, but were merely convulsive in their character. Intense cold also gave rise to these irregular movements.

Electric examination.—There was some difficulty in determining the state of the muscles as to their electric sensibility, owing chiefly to the want of intelligence in the patient, and to the fact that he spoke an impure German patois, which made it no easy task to obtain from him a clear statement of his feelings. The electro-muscular contractility is slightly diminished in the right leg and arm; it is much impaired in the extensors of the toes on both sides; everywhere the muscles respond slowly. The patient was discharged December 14, 1863.

CASE III.—WOUND OF RIGHT THIGH, WITH PROBABLE COMMOTION OF RIGHT SCIATIC NERVE; PARTIAL PARALYSIS OF RIGHT LEG; REFLEX PARALYSIS OF RIGHT ARM; SPEEDY RECOVERY OF ARM; HISTORY UNFINISHED.

WILLIAM W. ARMLIN, *æt.* 23, born in New York, farmer, enlisted August, 1862, in company "D," 134th New York Vols. Healthy before enlisting, and except a slight typhoid fever in the fall of 1862, healthy up to the date of the wound, July 1, 1863, at Gettysburg. While kneeling on the left knee, the right knee bent at a right angle he was shot in the right thigh, on a line with the internal condyle of the femur, ten inches above it, and a little anterior to the artery. The ball passed upwards, backwards, and outwards, and emerged two inches below the tuber ischii, and one and a quarter inches external to it, just above the fold of the nates. Dropping his musket he fell on his face, weak, but not insensible; the right leg violently flexed for a moment. He felt very feeble, but especially so in the right arm, with which he vainly tried to aid himself. After a half hour the bleeding, which was not excessive, ceased, and he was able to stand on the left leg, but not on the right leg, and had scarcely any use of the right arm, which, it should be noted, was in no way hurt when he fell.

He managed to bind up the wound with a water dressing, and occasionally renewing it, lay two days on the field. When hit, he perceived no pain, but within an hour a burning attacked his instep, and has never left it, remaining neither worse nor better. Sensation, he is sure, was unaltered except on the sole; motion improved slowly, except in the flexors and extensors of the foot and toes. To his surprise, the feebleness of the right arm increased after he was put in bed, and indeed notably after the second day. Up to October 28 it improved slowly, but at this time he went home on furlough, and began to use a crutch, which again so weakened the arm as to alarm him, and deprive him, as at first had happened, of the power to feed himself. Rejecting a crutch on this side, he used a liniment on the arm, and it has now gained so much as to have

about one fourth the force of the left arm. It did not lose sensation at any time.

Present state, December 14, 1883.—General health good.

Nutrition.—Wounds healed. Leg below knee wasted, foot swollen, toes blue. Contraction of great toe in dexion. Measurements, 87 inches; above internal condyle the thigh measures, right 16, left, 17 $\frac{3}{4}$ inches; middle calf, right 11 $\frac{1}{2}$, left, 13 inches.

Voluntary motion.—He lifts the right thigh well, but complains of its weight. Knee motions very fair; has no extension or flexion of the foot or toes.

Sensation.—Tactility absent in sole of right foot, feeble in second toe on its dorsal face, absent on top of third toe, but elsewhere complete. Localization extremely confused, so that a touch on the toes is felt, but is referred to the instep. Surface analgesia of the sole, but deep pricking with a needle is felt in the sole. Hyperæsthesia of the posterior thigh muscles to a slight degree; marked soreness on pressure in the calf muscles, the short extensors of the foot, and its whole dorsal surface as well as the inside of the sole.

Pain.—The pain lies deep in the calf and extends outside, under and in the peroneal muscles, down the front of the leg, and over the dorsum of the foot, and to the external side. It is intense in the dorsum, but nearly absent in the sole. Water does not seem to ease the pain, which is of a burning character "like mustard." Hitherto nothing has aided it.

Electro-therapy.—The thigh muscles respond well. The right tibialis anticus has no electro-muscular contractility, but its electro-sensibility is highly excited, as is the case in all the muscles down to the foot. In the foot the electro-muscular contractility and sensibility are both lost, except that in some parts of the dorsum the sensibility cannot be tested readily for various reasons. It is certainly lessened. The right arm is still very feeble, especially below the elbow, and has lost in size. It measures comparatively as follows:

Dec. 2nd.	RIGHT ARM.	LEFT ARM.
	Fore-arm, 11 inches.	2 $\frac{1}{2}$ inches.
	Arm, 9 " "	5 $\frac{1}{2}$ " "

He is not left-handed. The arm is improving; the leg has remained unchanged during some time past.

Ordered.—First, a blister over the whole dorsum pedis. Dec. 23.—This has caused great relief and is to be repeated. The complete history of this case will be detailed elsewhere. Up to this present date, February 1st, 1884, the burning pain in the foot has been relieved, and the hand and arm have entirely recovered under the use of the douche, active external electricity.

The following cases are equally instances of reflex paralysis. We regret that owing to circumstances not under our control, they are less complete as to their symptoms and history than we should have desired.

CASE IV.—A Sergeant was shot during the battle of Malvern Hill, in the right testicle. This organ was nearly entirely destroyed by the ball. He fell without pain, believing himself wounded in the back. A few moments later he became senseless. Recovering after a few minutes he discovered that he could walk, but that the right foot dragged when he attempted to lift it during the effort to get to the rear. This weakness remained permanent for several months, and was relieved by faradization and shampooing soon after the testicle healed. The flexors of the foot on the left leg were completely paralyzed to voluntary control, but responded to the irritation of the induced electro-magnetic current. There was no loss of sensibility.

CASE V.—The next case was observed by one of us in the U. S. A. General Hospital, 16th and Filbert Streets. Unfortunately no notes were taken at the time which will account for the brevity of the details.

An officer was struck by a small fragment of shell upon the external side of the left thigh. He felt pains of a smarting character in both thighs, at or about the same spot, and was impressed for a time with the conviction that he had been shot through both thighs. The shell wound healed in the course of three or four months. During this time he had occasional smarting on the outside of the sound thigh. This gradually disappeared, and at length he noticed accidentally that there was a space of skin about five inches square, on the outer part of the sound thigh, in which there was neither sense of touch nor of pain. When examined by us, he could indicate the boundaries of the anæsthetic space very readily, by the loss of tactile sensations when a body, moved while in contact with his skin, was made to cross the line on to the numb parts. These bounds were always very accurately the same. He returned to his regiment without any improvement having taken place in regard to anæsthesia. It is difficult, as it appears to us, to refer either this case or the last to any cause except a reflex effect. The interest of the case just now recorded, lies partly in the fact that at the time of the wound the patient felt a sensation which he referred to the part which afterwards became deprived of sensation.

The following case is a still more remarkable instance of the same peculiarity, and is also instructive from its resemblance to Case No. 3, that of ARMLIN, in whom a gun shot wound of the right leg also caused reflex paralysis of motion only in the arm of the same side:

CASE VI.—GUN SHOT WOUND OF RIGHT THIGH; LESIONS OF MOTION AND SENSATION; REFLEX PARALYSIS OF RIGHT ARM AS TO MOTION.

DANIEL KENT, *æt.* 24; Pennsylvanian; Farmer. Enlisted, August, 1862, company "B," 145th Pennsylvania Volunteers. Healthy until wounded. At Gettysburg, July 2d, 1863, while charging at a full run, the leg raised up, he was shot in the right thigh, 10½ inches above the edge of the patella, directly over the rectus. The ball made its exit on the postero-internal surface of the thigh, one inch below the fold of the nates. It seems to have passed inside of the bone and could not have hit the sciatic nerve. He fell at once, quite conscious and feeling an instant stinging pain all over the right side of his body, and especially in the arm. He lost a great deal of blood, and found that he could not sit up without giddiness. His wound was dressed in six hours, and he was on the field thirty-six hours. The leg lost all motion and some sensation, and the stinging pain in the arm left him within twelve hours. He remained in bed six weeks, and then was able to walk on crutches. The sense of touch changed but little during the time which has since elapsed, and the power of movement in the leg has remained unaltered since August 1, 1863. The wound healed in October, with some previous loss of bone. Since October the wounds have twice reopened to give exit to small pieces of bone. Except an attack of ague in October, his general health has been good.

Present condition, December 26, 1863.

Nutrition.—The leg is healthy in color; the foot swells when hanging down. The right thigh, eight inches above the patella, measures 19 inches in circumference; the left measures 19½ inches. The right calf measures 14½ inches; the left calf measures 15 inches.

Sensation.—No pain anywhere; tactile sensibility entire; sense of locality healthy.

Motion. The thigh is voluntarily flexed very slightly, and only through the agency of the psoas muscle, the anterior thigh muscles refusing to obey the will; abduction and adduction of the thigh normal; extension of the thigh is normal; extension of leg none. The foot is almost moveless, except that the will can cause feeble flexion of the toes, and slight eversion and inversion of the foot.

Electric examination.—The rectus muscle has its electro-muscular contractility somewhat lessened; that of the two vasti muscles is lost until the wet conductors reach the upper parts of the muscles (three inches above the wound) where this property becomes normal. The sartorius has its electric contractility diminished. Below the knee the peroneus longus responds very well, but with this exception, none of the leg muscles stir under the most powerful induced currents. The short extensor of the toes and the interossei still possess some power to contract under electrical stimulus. Throughout, the electro-muscular sensibility is diminished in all the muscles which have suffered in their contractile power, and the sense of pain seems also to be materially lessened since dry electric conductors, with strong currents, cause no pain when applied to the bones or nails of the foot.

The history of the arm, which was reflectively paralysed, has been reserved for separate detail here.

After three days from the date of the wound, the right arm, which had remained feeble, became so completely paralyzed that the patient could no longer raise it to his lips; under the use of a stimulating liniment it grew better until he used crutches. Probably owing to their employment he became much worse, but gradually improved again up to this present date of January 6, 1864. The right and left arms measure nearly the same; power of right arm one-fourth that of left.

Electric examination.—Electro-muscular contractility normal; electro-muscular sensibility somewhat lessened.

Treatment.—Faradization of arm daily; alternate hot and cold douche, and active motion.

On close examination, soon after admission, some evidence of tubercle was found in the right lung, and the patient was therefore ordered to be discharged January 29, 1864.

CASE VII.—WOUND OF RIGHT DELTOID; SENSORY AND SLIGHT MOTOR PARALYSIS OF RIGHT ARM; SPEEDY RECOVERY.

MICHAEL FARRELL, *et al.* 28, farmer, born in New York, enlisted, September, 1861, company "I," 20th New York Vols.; a vigorous, healthy looking man—was well up to date of enlistment. At Fredericksburg, December 13, 1862, he was shot in the left shoulder while lying down. The ball entered the erector spinae mass of muscles on the left side, on a level with the lower angle of the scapula, and passing upwards and outwards, lodged under that bone; the wound healed readily, the ball remaining. February 3, went to duty. July 1, 1863, a small ball passed through the right deltoid muscle, three inches above its insertion into the humerus. The rounded fell from his hand, and the arm dropped. He retired to a hospital, and on examination, found that although he had all the movements of the arm he had no sensation.

During the next four days he was exposed to the sun a good deal, and the arm, being bare, was blistered, which, he says, to a great extent, restored its feeling, which has since gone on improving. There is now, July 25, 1863, some slight paralysis of motion, but all the movements are feeble, and those of the arm painful, owing to the contractions about the ball track; the arm improved, and the man returned to duty October 22, 1863.

Before proceeding to discuss the causes which give rise to reflex paralysis, it will be useful to analyze the symptoms of the preceding cases, so as to learn how they differ, and in what respect they resemble one another.

RELATION OF THE SEAT OF THE WOUND TO THE PART OR PARTS PARALYZED.

CASE I.—The wound involved the muscles of the neck or throat, and the hyoid bone. *Result.* Paralysis of both arms, and of the neck.

CASE II.—Fragment of shell; wound of muscles over and external to the right femoral artery. The injury may have caused concussion of the crural nerves, and thus much of traumatic paralysis. *Result.* Reflected paralysis of the right arm and leg, and the left leg.

CASE III.—Probable injury of the sciatic nerve—(commotion.) *Result.* Reflex paralysis of the right arm.

CASE IV.—Ball wound of right testicle; paralysis of right anterior tibial muscles and peroneus longus.

CASE V.—Wound by fragment of shell in external side of left thigh; paralysis of tact on a corresponding part of right thigh.

CASE VI.—Ball wound, probably involving the crural nerves. *Result.* Paralysis of right arm.

CASE VII.—Ball wound of deltoid muscle; sensory and slight motor paralysis of same arm.

There is no evidence in this case that the ball struck the bone or directly injured any large nerves, since even the deltoid itself had nearly full power when the patient was first examined by us. In three of these cases the leg was hit, and the arm of the same side was paralysed. In three cases the paralysis affected the opposite side of the body, and in one the paralysis of tact and pain was observed to have fallen upon a space symmetrically related to the wounded spot as regards position.

No general law, therefore, can be deduced from these records, nor from what we see in the causation of reflex paralysis from disease should we expect to find any inevitable relation between the part injured and the consequent paralysis. The constitutional condition at the time of the wounding, as to excitement, mental and physical, may possibly have to do with causing the resultant paralysis.

Of the seven cases above reported, two were in active movement, two were standing about taking aim, one was kneeling, and of two we have no information as to this point. It may prove, upon examining a larger number of cases, that a man wounded when moving violently, or when excited, is more than another liable to reflex paralysis, but as yet we are not entitled to such an inference. In most of our cases the constitutional effects were instant and severe, and could not therefore have been due to the loss of blood, which in some of them was copious. Four of the seven cases had stinging, smarting or burning pain in the part paralysed reflectively. The pain was an early symptom which disappeared in all of them after a time. In three cases no such pains were complained of.

The after history of these cases is extremely curious. However grave the lesion of motion or sensation, it grew better early in the case, and continued to improve until the part had nearly recovered all its normal powers. In almost every instance some relief of the paralysis remained, even after eighteen months or more from the date of wounding. In some, the part remained weak, in others, there was still left some slight loss of sensibility, and in two the loss of power and of sensory appreciation was very considerable. In a case of reflex paralysis from a wound we have, therefore, some right to expect that the

patient will recover rapidly up to a certain point; then in most cases a small amount of loss of power or sensation may remain. The future history of our own or other cases may determine hereafter, whether the recovery is ever quite complete.

In case 1, the more prominent results were only the continued lesions which had been noted early in the case.

In case 2, the permanent lesions were chiefly of secondary character, and were at all events additions to those which were first observed.

In no other case were similar phenomena noticed. In two of the seven cases there were lesions of sensation and motion. In three, motion alone was lost, and in two the sense of tact and of pain were affected without other loss of function. The extent and duration of the induced paralysis have already been considered.

Of the treatment we have very little to say. In Captain STEMBEL's case the left arm recovered without treatment in four weeks, leaving only a slight loss of touch in the terminal distribution of the ulnar nerve. The right arm, which we also regard as reflectively paralyzed, recovered sensation early, but was useless as to motion, until it was treated and cured by faradization, eighteen months after it was first injured.

DEMMUTH, case 2, came under our care seven months after he was wounded; as to his previous treatment we know nothing. In our hands strychnia not only failed to aid him, but did harm. He was rapidly relieved by faradization, active and passive movement, and the douche, with iron, quinine and liberal diet.

ARMLIN, case 3, used a liniment on the paralyzed arm, with some improvement. Faradization has restored it completely.

Case 4. Relieved by faradization.

Case 5. No treatment; lesion of sensation only.

Case 6. KENT. A stimulating liniment applied upon the arm seems to have been of use. As in case 3, the employment of crutches caused a relapse.

Case 7 seems to have been accidentally benefited through the blistering to which the arm was subjected after exposure to the sun—a useful hint in like cases. No other treatment was employed.

Although long periods had elapsed in every case before we examined them, in only one, that of ARMLIN, case 3, was there any very notable wasting. And even in this patient the loss was generally throughout the member, and may be readily ascribed to mere lack of use. In none was there atrophy, such as characterizes lesions of nerves, and certain rheumatic and other palsies, save, perhaps, in the doubtful instance of the right arm in case 1.

The electric examination was made at periods so variable in the several cases, as not to permit of any useful comparison of results, and has been stated in each case merely for future use and reference when more cases have been reported. In only one case did the muscles display great loss of contractility when faradized, and in this No. 1 of the series, the limb in question was the right arm, as to which alone, some doubt may exist concerning the cause of the paralysis. The ultimate causation of these very singular and hitherto undescribed affections is the last point which we shall consider. The problem before us may be simply and briefly stated; its solution is a task less easy.

A gun shot wound occurs, involving large nerves or not, and we have instantly a paralysis of motion and sensation, or of either alone in some part of the body more or less remote. How shall we explain this? Although we have long been aware that certain forms of disease are capable of causing paralysis of distant organs, of altering secretions and

affecting nutrition, we have had no plausible theory of the causation of these effects until M. BROWN-SÉQUARD attempted to account for them in a manner equally simple and ingenious. Recalling the fact that irritation of the vaso-motor nerves is capable of producing contraction of the bloodvessels, he inferred that when an external nerve is violently or permanently excited, it may be able to produce contraction of the capillary vessels of the nerve centres, and thus give rise to paralysis. It seems unlikely, even if we admit his explanation, that the capillaries could remain contracted for any great length of time. But it is possible that the alteration of nutrition, which this temporary anæmia causes, may give rise to one of two results, either a continued disturbance of nutrition, which, however slight, would occasion grave results if it existed in a nerve centre, or secondly, to a paralysis of the capillaries of the nerve centre involved.

We suppose, first, the existence of an exterior nerve lesion; secondly, a consequent irritation of the vaso-motor nerves in a limited part of the spine; contraction of its capillaries, anæmia, nutritive changes, and finally, a relaxation of these vessels, which would be more apt to be a lasting condition, and would in fact constitute congestion. Such a series of consequences may very possibly occur, and would no doubt be competent to cause a paralysis, whose site, extent, and character would depend upon the part of the nerve centres affected by the excitation. With so satisfactory an hypothesis before us in this modified shape, it would seem needless even to suggest any other explanation. But in a region of research so little explored, it may be allowable to point out the fact, that another mode of explanation is at least possible, and the more so, since there exist certain objections to M. BROWN-SÉQUARD's manner of viewing the subject.

It is to our minds improbable that contraction of the capillaries can continue for any great length of time. There is no experiment on record to show that this can be, or that it ever occurs in a nerve centre. We have therefore added the suggestion of consequent, and why may we not say primary paralysis of these vessels. Here we have firmer ground for opinion, since it has been most distinctly shown that in section of the sympathetic nerve this result does take place, and is singularly persistent. But whether the bloodvessels remain contracted or dilated nutritive changes would occur, and these the pathologist has failed to find. If now we ask ourselves the question, whether it may be possible to blight or exhaust utterly the power of a nerve centre, without the intervening mechanism of contracted or dilated bloodvessels, we are tempted to think that such a result may be producible.

It appears to us possible that a very severe injury of a part may be competent so to exhaust the irritability of the nerve centres, as to give rise to loss of function, which might prove more or less permanent. A strong electric current, frequently interrupted, is certainly able to cause such a result in a nerve trunk, while a general electric shock, as a stroke of lightning, is, as we well know, quite competent to destroy the irritability of every excitable tissue in the economy. Now if the former of these results can occur in a nerve so insulated, as practically to have no circulation, the loss of irritability cannot be set down as due in such a case to a defect of circulation. Reflecting then upon the close correlation of the electrical and neural force, it does not seem improbable that a violent excitement of a nerve trunk should be able to exhaust completely the power of its connected nerve centre. The central change thus brought about would no doubt involve the consequent or immediate occurrence of chemical nutritive changes, which would gradually yield as

time went on. While this view seems to us adequate to explain the facts, the notion of vaso-motor irritation and capillary contraction (BROWN-SÉQUARD) does not appear to be competent to cover *all* the facts.

We have pointed out that no one has ever shown that capillary contraction can exist as a permanent state in a nerve centre. While on the other hand, it has been proven that section of a sympathetic nerve involves permanent dilatation of bloodvessels; but in the brain, which is supplied by the sympathetic of the neck, division of this nerve gives rise to no disturbance, although the side of the brain on which the section occurs grows warmer. However, it is probable that the whole supply of vaso-motor nerves to the brain does not come from the neck, while other organs, whose whole supply we can cut off, as the kidneys, do certainly suffer nutritive changes as a consequence of such sections.

One or other of the two theories we have offered must therefore be called on to explain the central changes which give rise to reflex paralysis. Either the shock of a wound destroys directly the vital power of a nerve centre, or it causes paralysis of the vaso-motor nerves of the centre, with consequent congestion and secondary alterations. But there is no reason why if shock be competent to destroy vitality in vaso-motor nerves or centres, it should be incompetent so to effect the centres of motion or sensation. Until the causation of these cases is better understood, it is vain to speak confidently as to treatment founded on a conception of the mode of their production. Experience has shown that the removal of the first cause, and in some instances the application of alteratives, as blisters to the cicatrix, prove valuable in relieving such induced pain as may exist. Further, that stimulating liniments or blisters to the affected member are useful, and that the local application of induced electric currents to the muscles is of the utmost service.

The question of the use of internal remedies has yet to be decided by larger clinical experience. We, ourselves, have been unfortunate in that no chances have presented themselves of treating these cases in their early stages, when the causes which first produce the paralysis are present and before those later nutritive changes occur which, as we presume, are essential to the continued existence of the state of palsy. We have endeavored to show in this report that the condition called shock is of the nature of a paralysis from exhaustion of nerve force; that it may affect one or many nerve centres, and finally, that it may be so severe as to give rise in certain cases to permanent central nerve changes, productive of paralysis of sensation and motion, or of either alone.

S. WEIR MITCHELL,
GEO. R. MOREHOUSE,
W. W. KEEN, JR.,

Act. Asst. Surgeons, U. S. Army.

U. S. GENERAL HOSPITAL,
Christian St., Philadelphia, Penn.,
February 15, 1864.

